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THE RELATIONSHIPS OF *HEMICAULODON EFFODIENS* COPE 1869 (MAMMALIA: ODOBENIDAE)

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Introduction

In 1965, while reviewing the older literature in connection with studies of fossil pinnipeds of the eastern United States, I happened upon the type-description of *Hemicaulodon effodiens* Cope 1869, described on the basis of an incomplete tusklike tooth thought to be an upper incisor, from a marl pit at Shark River, Monmouth County, New Jersey, as an Eocene sea cow, but obviously, from a glance at Cope's excellent illustrations, the basal part of the tusk of an advanced, probably Pleistocene, walrus. As the name seemed not to have entered into the literature of fossil walruses, a search was made to learn its disposition, revealing that for the most part it had been overlooked or ignored, for example in otherwise comprehensive modern works on the Mammalia (Simpson, 1945), on the Sirenia (Simpson, 1932; Reinhart, 1959), and on fossil vertebrates of New Jersey (Miller, 1955). When noticed at all, it generally has been mentioned or listed as an Eocene sirenian: without question, by Gervais (1872a, p. 169; 1872b, p. 352), Cope (1883, p. 52; 1890, p. 699, as *Hemicaulodon effodens*), Heilprin (1887, p. 340), Roger (1887, p. 30, as from South Carolina, in error), Trouessart (1898, p. 1006; 1905, p. 751), Hay (1902, p. 583; 1930, p. 657), Rhoads (1903, p. 246), and Palmer (1904, p. 316); with question, by Lepsius (1882, p. 185), Zittel (1893, p. 201, listed incertae sedis, as an inadequately founded genus), Roger (1896, p. 249, incertae sedis, as from South Carolina, in error), and Allen (1923, p. 231). Leidy (1869, p. 440), followed by Brandt (1873, p. 290), placed *Hemicaulodon effodiens* among the toothed whales, but with characteristic astuteness, implied that it might represent a walrus-like animal, just as might *Ontocetus emmonsi*, about which he was quite correct also (Ray, in press). Kellogg (1924, p. 757) regarded the allocation of *H. effodiens* as "too uncertain at present for any discussion of its possible relationships," but seemed to imply cetacean or sirenian affinities, whereas he later (1966, p. 78) regarded it definitely as a dugongid sirenian. Reinhart (in press) concurs that it is a walrus. To my knowledge the above include all published indications of relationship of *Hemicaulodon effodiens*. Several citations of the name (Roger, Trouessart, and Rhoads) give its year of publication erroneously as 1871, which is the year indicated on the title page of whole volume XI of the Proceedings of the American Philosophical Society, but not of part No. 82 therein, which was published in 1869.

The present notes are published now in order to make them available to others engaged in the completion of relevant comprehensive studies, and to call attention to the taxon in the hope that its type-specimen may be rediscovered.

FATE OF THE HOLOTYPE

Sporadic efforts from 1965 to the present to find the holotype have thus far failed to locate it in the collections of the following institutions: Academy of Natural Sciences of Philadelphia (ANSP); American Museum of Natural History (AMNH); Monmouth County Historical Association Museum; National Museum of Natural History (USNM); New Jersey State Museum; Peabody Museum of Natural History, Yale University; Princeton University, Department of Geology; Rutgers, the State University, Department of Geology.

The specimen was originally in the private collection of the Reverend Samuel Lockwood, an avid amateur naturalist, who was for 15 years pastor in Keyport, New Jersey, before resigning in August, 1869, and moving to Freehold in 1870 (John Enright, 1885, p. 449). There is no certainty that Cope ever had the specimen in his possession, and, although explicit information is lacking, there is considerable circumstantial evidence that he did not, based upon the sequence of events relating to the description of *Ornithotarsus immanis*, a very large hadrosaur, that commanded greater attention in publication, correspondence, and records.

Although quoted already by Lull and Wright (1942, p. 4), Lockwood's colorful account of a visit from Cope, apparently only a few days prior, will stand repeating for its bearing on *Hemicaulodon*:

> Just as I was about packing the bone [of *Ornithotarsus immanis*] to send to Mr. H. [Waterhouse Hawkins] (I actually had it in the box) a gentleman knocked at the door. He had a very large carpet bag and announced himself as Prof. Cope. He had smelt the bone & come for it. But no sir that could not be. Well, he would see it & see it he did, & took drawings of it. Thus [?] I found this stranger a remarkable man. If the sibyl could declare in dubious language Alexander is invincible, I can say literally as regards Prof. Ed. C. that this humble individual could not cope with him. He is the man to seize your very bones. (Marsh correspondence, Peabody Museum, letter from Lockwood to Marsh of May 20, 1869).

Cope exhibited the drawings and introduced the scientific name at a meeting of the Academy of Natural Sciences of Philadelphia on June 1, 1869. He introduced *Hemicaulodon* in the Proceedings of the American Philosophical Society for July 16 of the same year, probably after having made drawings and notes during the same visit to Lockwood. At about the same time Lockwood did however lend Cope for description a plesiosaur vertebra, which became the type of *Plesiosaurus lockwoodii* (see Welles, 1952, p. 113, for citations to the confusing literature).

Thus Cope described at least three taxa from Lockwood's collections. Of these, at least one, *Ornithotarsus immanis*, became part of the Marsh collections at the Peabody Museum, having been sent by Lockwood on March 16, 1886, and received on March 18, 1886, according to the records under Accession No. 1830. The shipment consisted of only "one box (express $1.00) containing type specimen of *Ornithotarsus immanis* Cope. . . .," with no reference to other material. The only explicit reference to *Hemicaulodon* found in the Marsh correspondence is in a list of specimens enclosed with a letter from Lockwood to Marsh of March 21, 1886, in which *Plesiosaurus lockwoodii* is listed as well, indicating that both were still in Lockwood's possession at that time. Whether these were purchased subsequently by Marsh seems to be unknown, though probable. Kellogg's (1966, p. 78) footnote indicating that the type was purchased by Marsh in March 1886 was based upon my findings in the Marsh correspondence, which were not as conclusive as his statement suggests. In any case, none of the specimens has been found in the Peabody Museum in repeated searches by several individuals since 1965.

Rhoads (1903, p. 247) stated, "Type may be in Amer. Mus. Nat. Hist., N. York," perhaps on the basis of the purchase of the Cope Collection of North American fossil mammals by the American Museum of Natural History in 1895 (Osborn, 1931, p. 446). There is no positive evidence that the specimen was included in this collection, and apparently it is not now in the American Museum.

Characteristics of the Holotype

Although, without the holotype in hand (and possibly even with it), a firm decision as to its specific affinities cannot be made, its identity as the basal, intra-alveolar portion of the tusk of a modernized walrus is evident by inspection of Cope's excellent illustrations, here reproduced, enlarged to natural size (Pl. 1 and Pl. 6, Fig. 3). Cope (1869, pp. 190–191) noted essentially all of the salient features of the holotype that make it distinctively odobenid, and distinctively not sirenian or cetacean, and even compared it to the odobenids *Trichecodon* Lankester and *Ontocetus* Leidy, the latter unfortunately regarded by him at the time as sirenian. His failure to reach the correct conclusions from his keen observations of pertinent characters may be traced primarily to the assumption of Eocene age, to the erroneous belief that the tooth was essentially complete with a part of the triturating surface preserved, and to the paucity of comparative material. The

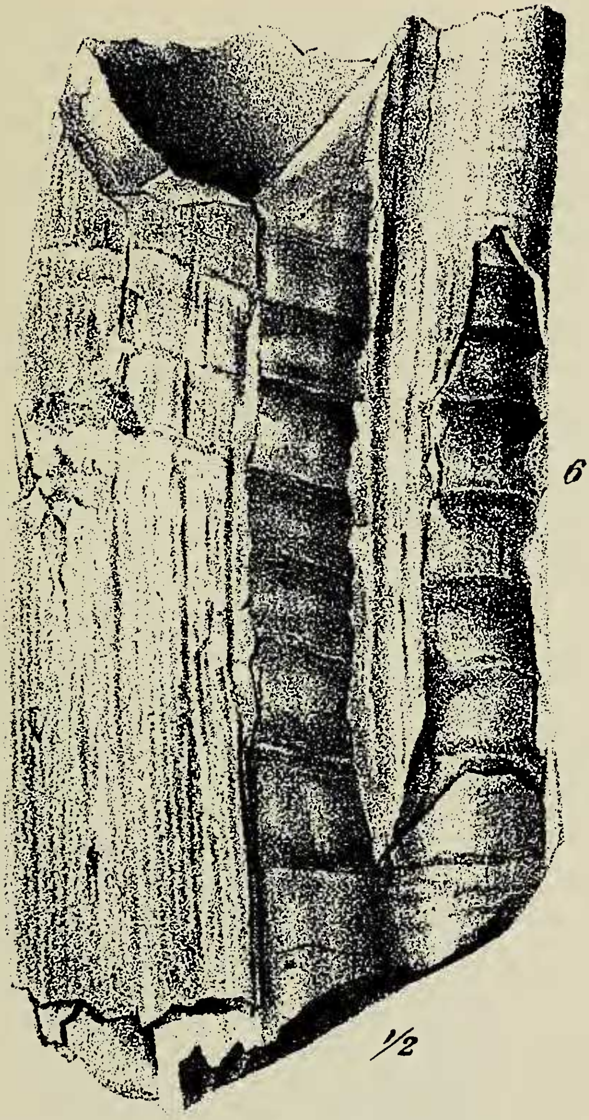

PLATE 1. The holotype of *Hemicaulodon effodiens* in medial (?) aspect. After Cope, 1869, Pl. V, Fig. 6. Original × ½, here enlarged to approximately × 1.

characteristics of the tooth may be discussed conveniently under the general topics of structure, form, and surficial features.

Structure: As Cope illustrated and aptly stated, "The substance of the tooth is composed of a large axis of osteo-dentine surrounded by a broad cylinder of dentine, which is in turn surrounded by a thick stratum of cementum. . . . The cementum is everywhere entire, and is thicker distally. . . . The dentinal layer is about one half the thickness of the osteodental axis, and three times that of the cementum." The discrete, flattened-cylindrical core of globular osteodentine extending the length of the tusk is alone enough to exclude the specimen from all other Mammalia, and to identify it conclusively as odobenid (Pls. 3 and 6). Globular osteodentine probably occurs sporadically in many, if not most, groups of mammals, but is especially common in some forms with large tusklike teeth, including wart hogs (Penniman, 1952, Pl. XIII), dugongs (Pl. 5, Fig. 2), elephant seals (Pl. 5, Fig. 1), and odontocetes, especially sperm whales (Boschma, 1938, Pl. XIII; Pl. 4). Its occurrence and abundance in these groups seems to be variable, but, in elephant seals and sperm whales at least, it tends to be more prevalent in old individuals. In sperm whales the globules occur singly or in intergrown clumps in the soft tissue of the pulp cavity, where they may ultimately become imbedded here and there within successive layers of the dentinal laminae, possibly in part in annual pulses, but apparently never as a well-defined subcylindrical mass extending the length of the tooth. Occurrence in the modern dugong is negligible. The canines of old male elephant seals show the closest approach to those of walruses in development of globular osteodentine, but even there it occurs mostly as isolated lumps within the laminar dentine with at most a cone-shaped mass in part filling the pulp cavity in old

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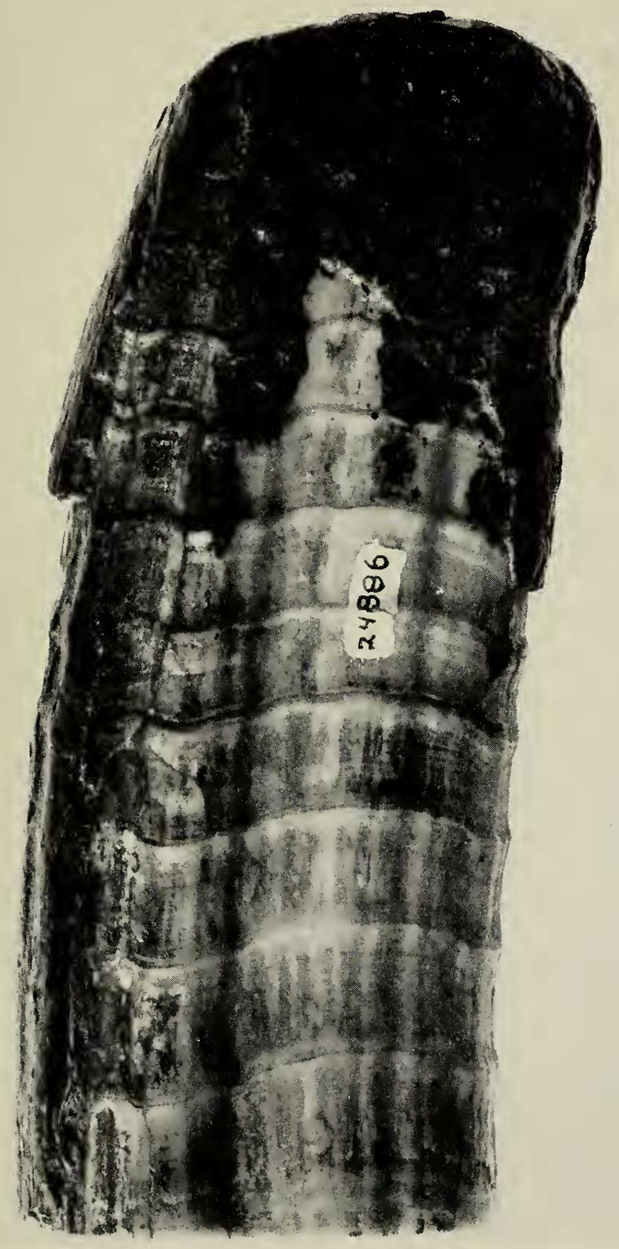
PLATE 2. Basal part of right tusk of Pleistocene *Odobenus rosmarus* in medial aspect, USNM 24886, dredged off North Carolina. Cementum spalled away from most of surface, revealing transverse annular ridges. × 1.


24886

age (as in a sectioned right upper canine of USNM 265353, an old male of *Mirounga angustirostris*, Pl. 5, Fig. 1).

In the course of his original description of *Trichecodon huxleyi*, Lankester (1865, pp. 228–230, Pl. 10, Figs. 4–6) clearly defined and illustrated the unique development of globular osteodentine in walrus tusks, noting that it was described as early as 1805 by Cuvier. Although Cope obviously had Lankester's paper at hand while describing *Hemicaulodon*, neither he nor apparently most authors who have studied isolated fossil teeth of marine mammals to date recognized the utility of this feature in identifying walrus tusks.

As Cope pointed out, the tusk of *Hemicaulodon* differs from those of dugong and *Rytiodus* in having a complete sheath of cementum and no enamel band. The tusks of modernized walruses have only a short apical cap of enamel that is worn entirely away within the first few years of life (Mansfield, 1958, pp. 25–28, Fig. 5).

Form: Cope recognized the following salient features: "The form of the tooth is that of a compressed, slightly curved cylinder, with distal and proximal vertical diameters equal. . . . The transverse diameter posteriorly is less than that anteriorly. . . . The widths of the tooth increase very little from the basis to the worn surface." All of these characters and those revealed in the illustrations are appropriate to walrus tusks, and for the most part not to sirenian tusks. The posterior narrowing of the holotype in cross section is atypical of walrus tusks, but not unknown. The tusks of *Hemicaulodon effodiens* and *Rytiodus capgrandi*, with which Cope compared his specimen especially, are shown together in lateral and cross-sectional aspects by Gervais (1872b, Pl. XIX, Figs. 1, 1a, 2, 2a), revealing clearly their dissimilar shapes, the tusk of *Rytiodus* being irregular and noncylindrical in shape with varied transverse dimensions along its length, curved conspicuously in two planes, and extremely compressed. Tusks

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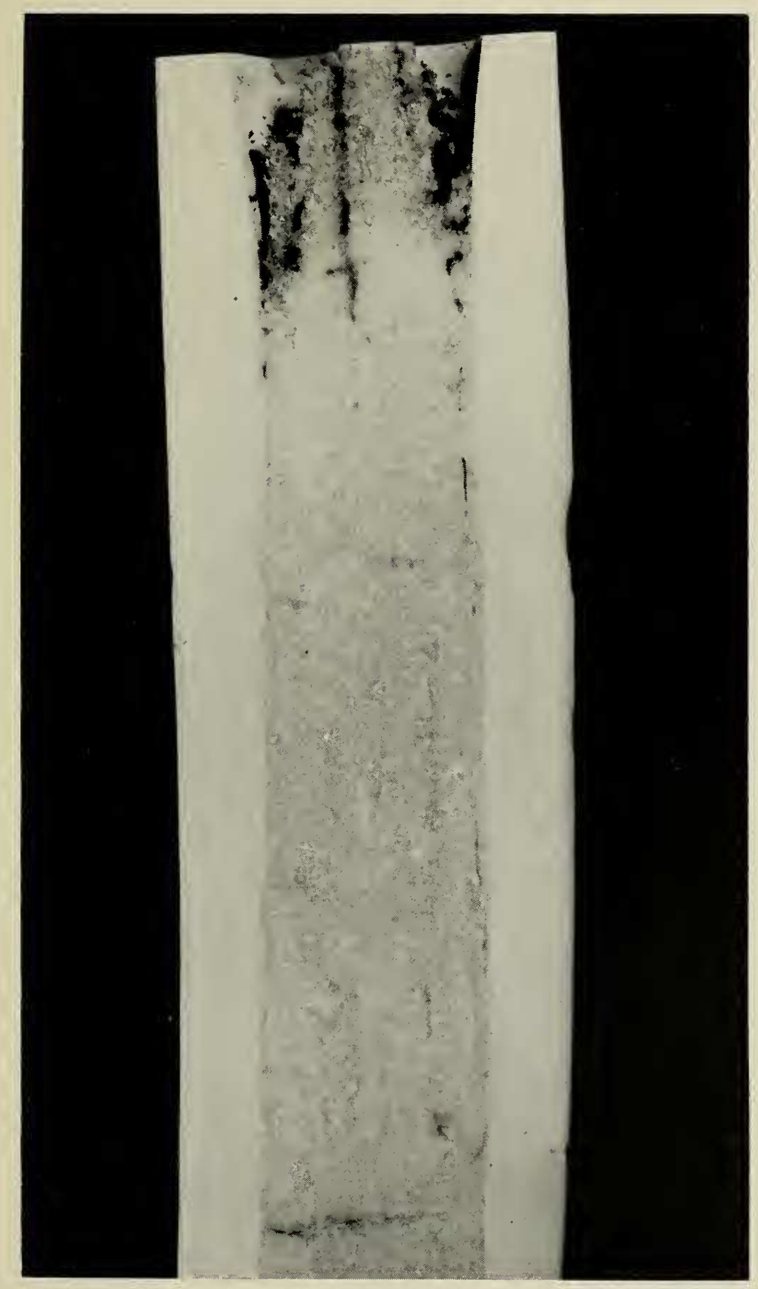
Plate 3. Longitudinally sectioned basal part of right tusk of Recent *Odobenus rosmarus* in internal aspect, USNM 21667, showing core of globular osteodentine. × 1.



of modern dugongs are superficially similar to the incisors of rodents in general form, with more nearly equal transverse diameters, none of which approach those of *H. effodiens* or modern walrus tusks in size.

The ratio of least to greatest diameters (.61) of the holotype tusk is rather low for *Odobenus rosmarus*, though not outside its observed range, reflecting a degree of flattening more characteristic of tusks from late Tertiary beds (Ray, in press).

Cope contrasted the acuminate form of the tusks of *Trichecodon* and *Ontocetus* with the cylindrical form of that of *H. effodiens*. This unjustified emphasis of correct observations was based on the fact that his specimen represented the proximal, and the others, the distal, parts of walrus tusks. This misinterpretation is directly related to another, i.e., the supposition that his specimen represented a nearly complete tooth in which "a portion of the triturating surface is preserved; it truncates the tooth upwards and backwards in relation to its axis, as would be anticipated in a superior incisor [of a sirenian]." In fact the holotype represents only the proximal, intra-alveolar end of a walrus tusk. The "triturating surface" could indeed have developed in life in an individual walrus with a broken canine, a not uncommon accident among living walruses (Cousteau and Diolé, 1974, p. 174). The polished surface could equally well have been a postmortem phenomenon, judging from experience with other fossil walrus tusks. The durable rostrum of the skull will often remain intact through extensive rolling and abrasion, after the cranium has been separated or destroyed and the tusks broken off near the alveolar borders, and their stubs polished, yielding a "triturating surface" in approximately the right position and orientation for *H. effodiens*. Further tumbling might then break up the rostrum or cause the basal tusk frag-

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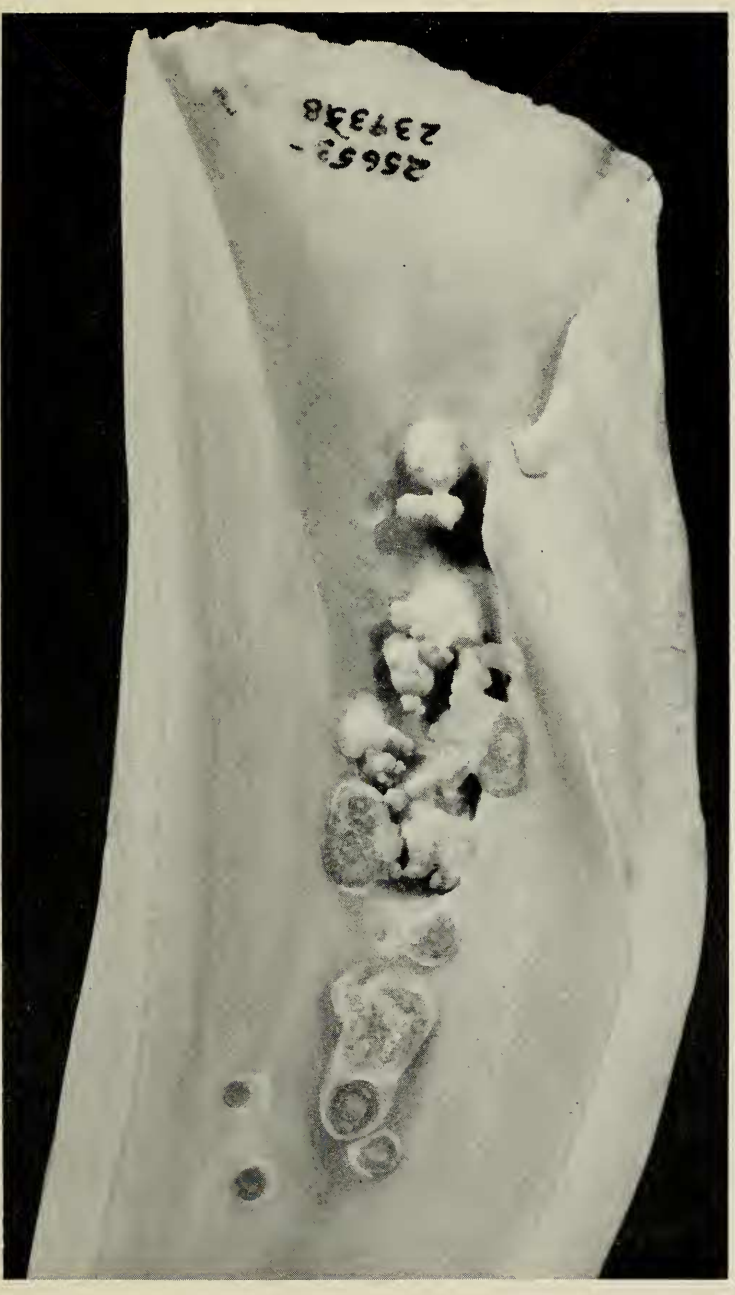
PLATE 4. Longitudinally sectioned tooth (distal 6 cm not shown) of Recent *Physeter catodon* in internal aspect, USNM 25653, showing irregularly distributed globules of osteodentine. × 1.



ment to slip out of its alveolus. Whether broken and polished in life or death, the proximal end of the tusk represented is typically walrus-like and could not be expected to show the acuminate form of the extruded distal end.

Surficial Features: These include "two open grooves on the inner and one similar on the outer side, the former enclosing a broad bead. . . . The dentine . . . marked at regular distances by annuliform ridges, which are more or less undulate. They become gradually more distant distally. These ridges can be traced through the cementum" (Cope, 1869, p. 190). The open grooves, two inner and one outer, are highly characteristic of walrus tusks, as are the transverse dentinal ridges. These ridges were described by Tomes (1904, pp. 195–196) who seems to have been the first to recognize that they reflect annual increments of growth, farther apart in youth (distal) and progressively closer in old age (proximal). They tend to be masked by cementum in unweathered tusks, both fossil and modern, except toward the proximal, intra-alveolar end—hence not apparent in the distal fragments of tusks of *Trichecodon* of Lankester (1865), but reflected in the cementum of Cope's proximal fragment. This condition is shown exceptionally well in modern tusks illustrated by Scheffer (1950, Fig. 3) and by Mansfield (1958, Fig. 7), but the ridges show best in weathered tusks in which some of the cementum has spalled cleanly away from the underlying dentine (Pls. 1 and 2; Brooks, 1954, Fig. 7; Mansfield, 1958, Fig. 8a).

Only Kellogg's (1966, p. 78) comparisons and conclusions regarding *Hemicaulodon* now require comment. He recorded three isolated teeth as incisor tusks of dugongids: USNM

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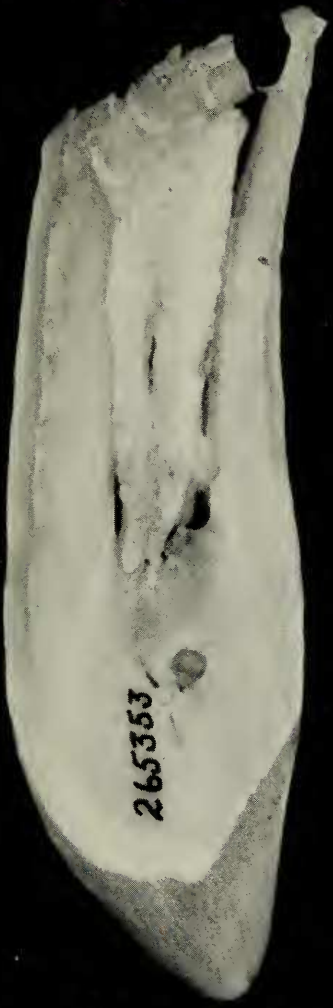
Plate 5. Fig. 1, longitudinally sectioned right upper canine of Recent old male *Mirounga angustirostris* in internal aspect, USNM 265353, showing isolated globules of osteodentine, and basal cone of osteodentine filling pulp cavity, × 1. Fig. 2, longitudinally sectioned left tusk (upper incisor) of Recent adult male *Dugong dugon* in internal aspect, USNM 284441, showing small amount of osteodentine embedded in laminar dentine near apex of pulp cavity, × 1.



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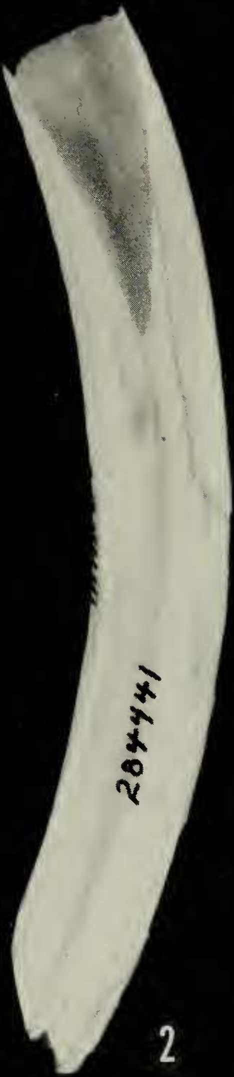

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9457, possibly from the Calvert Formation, Tar Bay, Virginia; AMNH 9852 (cast in USNM), dredged off Fort Myers, Florida; USNM 23110 (cast), probably from the Duplin Formation, near Savannah, Georgia. He felt that the major features, except size, of *Hemicaulodon effodiens* could be matched by USNM 9457 and by AMNH 9852. In fact, in addition to disparate size, these teeth differ from the holotype of *H. effodiens* also in lacking the osteodentinal core, the strong, widely spaced transverse dentinal ridges (fine, closely spaced transverse striae are present), and the compressed cylindrical shape with two inner and one outer groove (the transverse dimensions are subequal). All of these teeth can be matched within the variation of a large series of physeterid teeth from the Yorktown Formation of the Lee Creek Mine, North Carolina, and in my opinion represent sperm whales, not sirenians, and in any case bear little resemblance to *H. effodiens.*

Dr. Kellogg (1966, p. 78) perpetuated Cope's comparison of *Hemicaulodon effodiens* to *Rytiodus capgrandi*, but he informed me in subsequent discussion that he had been misled by the unfortunate juxtaposition in Cope's Plate V, of Figure 6, the holotype of *H. effodiens*, and Figure 4a, a human implement made from the shell of *Strombus gigas* from Anguilla, Lesser Antilles. This error caused him to visualize the former as much more compressed and therefore more like the tusk of *R. capgrandi* than is the case. When shown the illustrations of *H. effodiens* enlarged to natural size alongside known walrus tusks with cementum exfoliated, he readily agreed that *H. effodiens* is indeed a walrus (personal communication, 1966).

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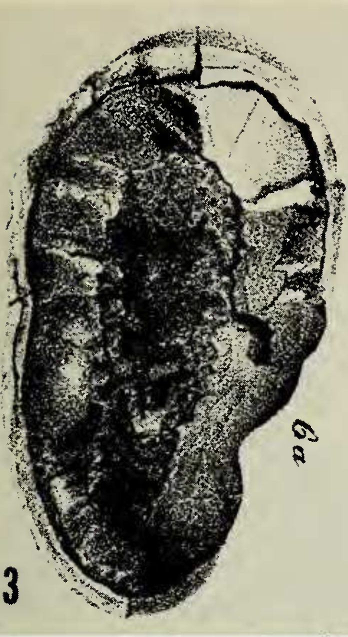
PLATE 6. Fig. 3, the holotype of *Hemicaulodon effodiens* in distal aspect, after Cope, 1869, Pl. V, Fig. 6a, original × ½, here enlarged to approximately × 1. Fig. 4, left tusk of Pleistocene *Odobenus rosmarus* transversely sectioned 11 cm from base, in distal aspect, ANSP uncatalogued specimen, dredged off New Jersey, × 1. Fig. 5, left tusk of Recent *O. rosmarus* transversely sectioned 15 cm from base, in distal aspect, USNM 219054, × 1. Fig. 6, right tusk of Pleistocene *O. rosmarus* transversely sectioned 16 cm from base, in distal aspect, USNM 24886, × 1.



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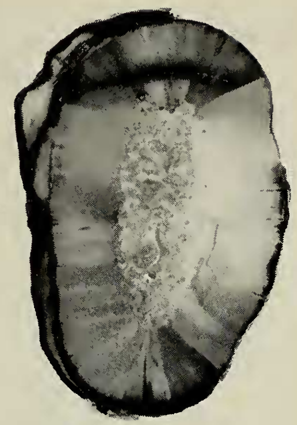

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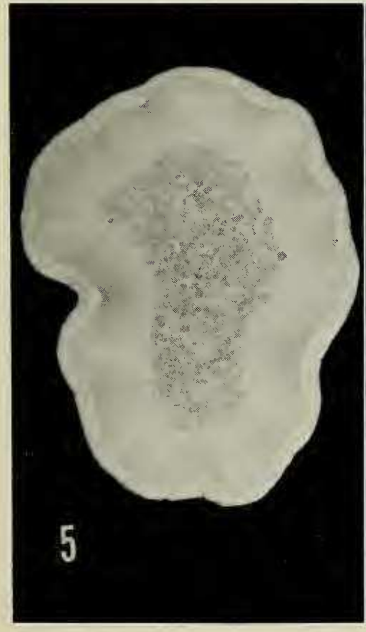

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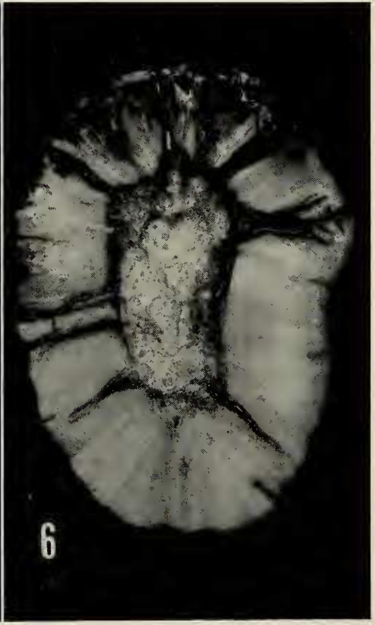

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TYPE-LOCALITY

With regard to the type-specimen Cope (1869, p. 191) stated that Lockwood "obtained it from the Eocene marl pits at Shark River, Monmouth co." Lockwood also indicated the locality as "Shark River" in his list sent to Marsh on March 21, 1886. Neither specified whether he referred to the River itself or to the settlement of the same name. However, in a letter to Marsh of November 17, 1881, Lockwood wrote, "I send you a small bone by mail. It was obtained in the Miocene marl, or green sand, at Shark River, Monmouth Co., N. Jersey (now known as Hamilton)." The village continues to be known as Hamilton, and is situated on the north side of the Shark River at approximately 40°12′30″ N, 74°05′ W, in the Asbury Park, New Jersey, quadrangle, U.S. Geological Survey, 7.5 minute series. Hamilton, formerly Shark River, is not to be confused with Shark River Station, which appears on some contemporary maps, sometimes with the word Station omitted. Shark River Station was a stop on the Central of New Jersey Railroad. It no longer appears as such on maps, but was located some 5.5 km WNW of Hamilton, where the still-existing Shark River road terminates at the railroad, in the northwest corner of the township of Wall, 1.1 km northward from Earle, in the Farmingdale quadrangle. Hamilton is somewhat less than 3.2 km upstream from the Shark River estuary, and the principal 19th century marl pits nearest to Hamilton were concentrated near the River some 1.6–3.2 km still farther upstream, immediately SW and W of interchange no. 100 of the Garden State Parkway (Cook, 1868, pp. 275–276; Ralph Johnson and Robert W. Purdy, personal communication). The locality probably cannot be established more accurately than "marl pit, near Hamilton, Monmouth County, New Jersey.

GEOLOGIC AGE

The general geology along the Shark River near Hamilton is probably permissive of a source for *Hemicaulodon effodiens* in Eocene, Miocene, or Pleistocene strata. Cook (1868, pp. 275–276, Fig. 71) gives a section of a typical marl pit of the time along the Shark River, the J.T.L. Tilton pit, apparently the pit closest to Hamilton (Robert W. Purdy, personal communication). The Eocene deposit here is the Shark River marl, an argillaceous glauconite sand, regarded by some authors in recent years as a member of the Manasquan Formation, but separated and redefined as the Squankum Member of the Shark River Formation by Richard Enright (1969, p. 18). The Eocene strata are overlain disconformably in the area by the Asbury Park and Grenloch Sand Members of the Miocene Kirkwood Formation, generally regarded on sparse paleontological evidence as in part equivalent to the Calvert Formation of Maryland (Isphording, 1970). The Grenloch Sand Member may not be readily separable from the overlying Cohansey Sand, which may or may not extend into Monmouth County (Markewicz, 1969). Pleistocene (?) gravels probably pertaining to the Pennsauken Formation are widespread in the area (Salisbury and Knapp, 1917, pp. 155–156; Bowman and Lodding, 1969) and at least around the Shark River estuary, as at Neptune City, there are thick late Pleistocene marine deposits. The recognition, distribution, geologic age, correlation, and paleoecology (marine vs. nonmarine) of all strata from the Kirkwood Formation upward remain uncertain, but all have been regarded at times as in part or in whole nonmarine, based in large measure upon the dearth of fossils.

In the original publication on *Hemicaulodon effodiens* Cope (1869, p. 191) indicated only that it was from the "Eocene marl pits," but in 1872 (p. 14) he noted that the Eocene "near to Shark River especially, [is] overlaid by a thin stratum of loamy sand, which contains fragmentary remains of terrestrial vertebrates of the Miocene period. . . . Whether . . . *Hemicaulodon* (Cope) and *Anchippodus* (Leidy) were derived from this or from the Eocene bed remains uncertain." Kellogg (1966, p. 78), unduly influenced by supposed similarities of the type of *H. effodiens* to later Tertiary specimens from eastern United States and to the tusks of *Rytiodus capgrandi*, stated as follows: "It is now suggested without hesitation that the type tooth was not derived from the middle Eocene Shark River marl. . . . Inasmuch as the Miocene Kirkwood formation overlaps the Shark River marl (Manasquan Formation), the association of any specimen picked up on the surface alongside or in a marl pit being worked could readily be misinterpreted." Lockwood (1885, p. 15), in his account of the paleontology of Monmouth County, stated that, "In the so-called Drift, one phase of the glacial period, we have collected in Monmouth County relics of the reindeer, walrus, and even a species of dugong." Throughout the publication Lockwood referred to himself in the plural, including explicit reference to his collecting the types of *Ornithotarsus immanis* and *Plesiosaurus lockwoodii.* The "species of dugong" could hardly apply to anything but *Hemicaulodon effodiens,* and suggests that Lockwood had come to suspect a Pleistocene age. Remains of Pleistocene walruses were recognized early along the coast of New Jersey (Leidy, 1857), and they continue to accumulate in substantial numbers (Kardas, 1965, and unpublished specimens). Donald Baird (personal communication) has pointed out that bones of *Mammut americanum* were recovered from the same spoil heap as the Cretaceous reptiles of New Jersey reported by Baird and Case (1966). This situation is familiar to anyone accustomed perforce to working with vertebrate remains from ditches, road cuts, dredgings, and spoil in the outer coastal plain with its low relief, deep weathering, poor exposures, and thin, unconsolidated deposits reflecting complex geologic history.

My interpretation of the affinities of *H. effodiens* would suggest a maximum age no earlier than the deposition of the Yorktown Formation, the source of the otherwise oldest known walruses in the Atlantic Coastal Plain. Thus the Shark River Formation, which antedates the origin of pinnipeds, is out of the question as a possible source, and even the Calvert-equivalent Kirkwood Formation is too old, barring the improbable possibility that *H. effodiens* is the oldest North Atlantic walrus by a considerable margin. The morphology of the specimen, so far as revealed in the original illustrations, does not serve to differentiate among Yorktown and younger walruses. In view of this and of the inexact type-locality and of uncertain identification and correlation of the later Cenozoic beds in the area, it is futile to speculate further about the geologic age of *H. effodiens*, at least until the type is found.

CONCLUSION

Hemicaulodon effodiens is definitely an advanced walrus on the basis of all details of structure, shape, size, and annulations of the type tusk. Similar tusks are known from the Yorktown to the Recent in and around the North Atlantic.

The most convenient and reasonable disposition of the taxon for the present is as a Pleistocene (?) representative and junior synonym of *Odobenus rosmarus*, with the proviso that its placement should be reappraised on the basis of morphology and possibly adherent matrix (noted by Cope, 1869, p. 190, in the pulp cavity) when the type is relocated.

ACKNOWLEDGMENTS

I wish particularly to acknowledge my debt to the late Remington Kellogg who listened patiently, responded flexibly, and encouraged publication of these findings. I wish also to thank the curators and staff of the various museums and institutions in which the type-specimen of *H. effodiens* or information about it has been sought. In addition certain individuals must be thanked individually for their extraordinary assistance. Foremost among these is Robert W. Purdy, who has shared his special knowledge of the paleontology and history of Monmouth County and has explored numerous leads in our search. Similarly, Donald Baird, James A. Hopson, Ralph Johnson, and John S. McIntosh, have provided useful information and suggestions. Louise Jost, Librarian of the Monmouth County Historical Association, Harmony Coppola, Secretary to the Archivist, Rutgers, the State University, and Melvin C. Krampf, historian, and columnist of the Freehold Transcript, have been extraordinarily helpful in seeking information about Samuel Lockwood. Charles O. Handley, Jr., and James G. Mead made the collections of Recent marine mammals of the National Museum of Natural History available, and permitted sectioning of selected specimens. The plates were prepared by Lawrence B. Isham from photographs taken by Victor E. Krantz. The manuscript was reviewed by Roy H. Reinhart and Frank C. Whitmore, Jr. The work on which this paper is based was supported by the Smithsonian Institution, in part through the Remington Kellogg Memorial Fund and in part through the Smithsonian Research Foundation.

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